The *hypobranchials* are elongated and, save for their anterior curvature, almost straight.

The *ceratobranchials* are slightly broader osseous palettes than in *P. erithacus*, and they are hardly as much curved.

It is interesting to find that this part of the anatomy of *Stringops* would alone suffice to declare the essentially Psittacine nature of the bird. It also proclaims it to be a peculiar Psittacine form. With no affinities whatever for the Loriidæ (so far as I have yet been able to examine that family), it is also very distinct from *Psittacus*. I have not been able to find any representation of a Psittacine hyoid to which that of *Stringops* shows any marked resemblance.

In conclusion I think we have, in the existence of the parahyal arch, a very distinctive character for at least three genera of Loriidæ; and, when we consider how closely allied other genera of that family are to *Lorius*, *Eos*, and *Trichoglossus*, we may, I think, expect to find that a general resemblance exists between the hyoids of the entire group. In other skeletal characters there are some interesting differences between *Psittacus* and *Lorius*, as I hope to be permitted on some future occasion to point out.

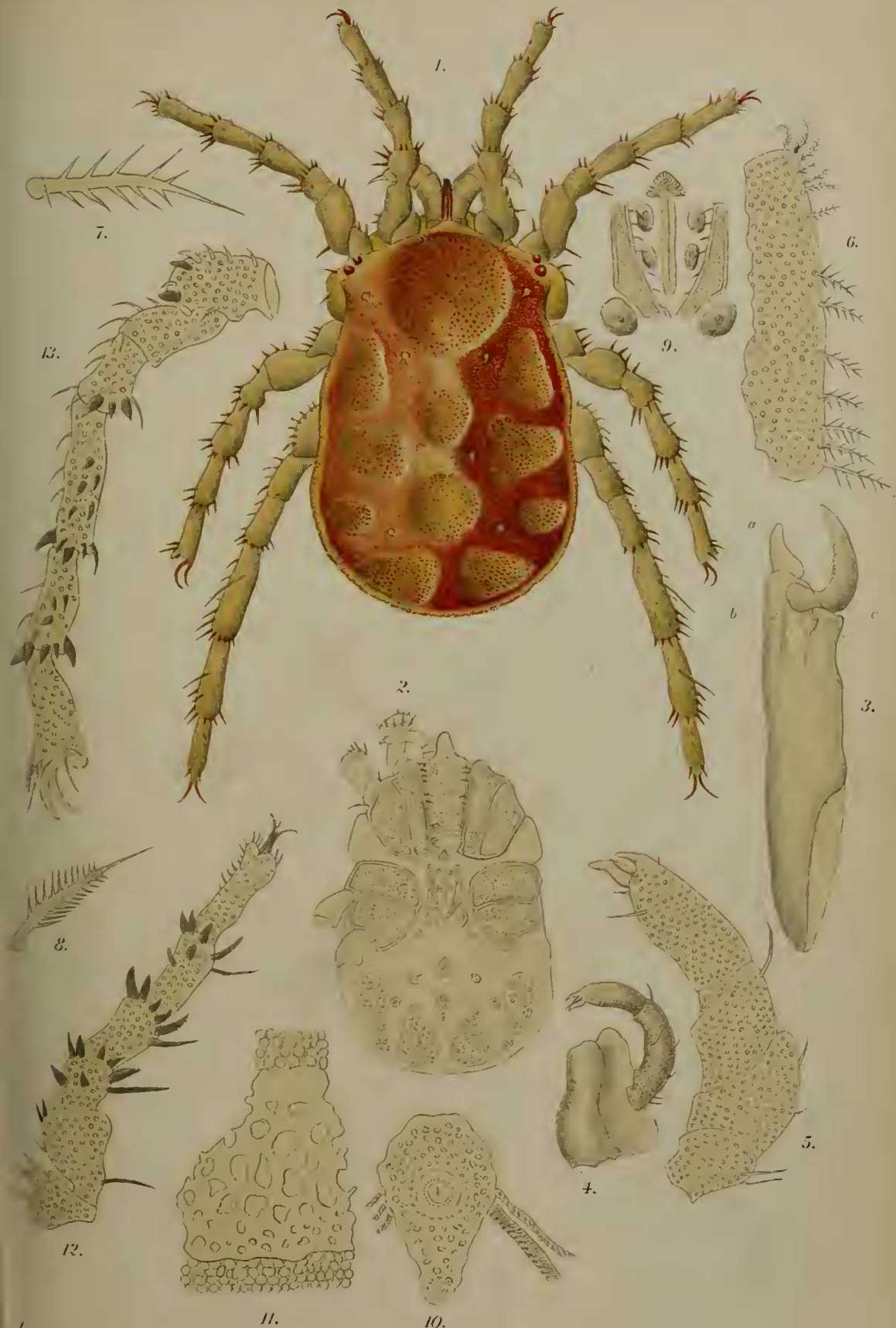
2. A Study of the Internal Anatomy of *Thyas petrophilus*, an unrecorded Hydrachnid found in Cornwall. By A. D. Michael, F.L.S., P.R.M.S., &c.

[Received February 27, 1895.]

(Plates VII.–IX.)

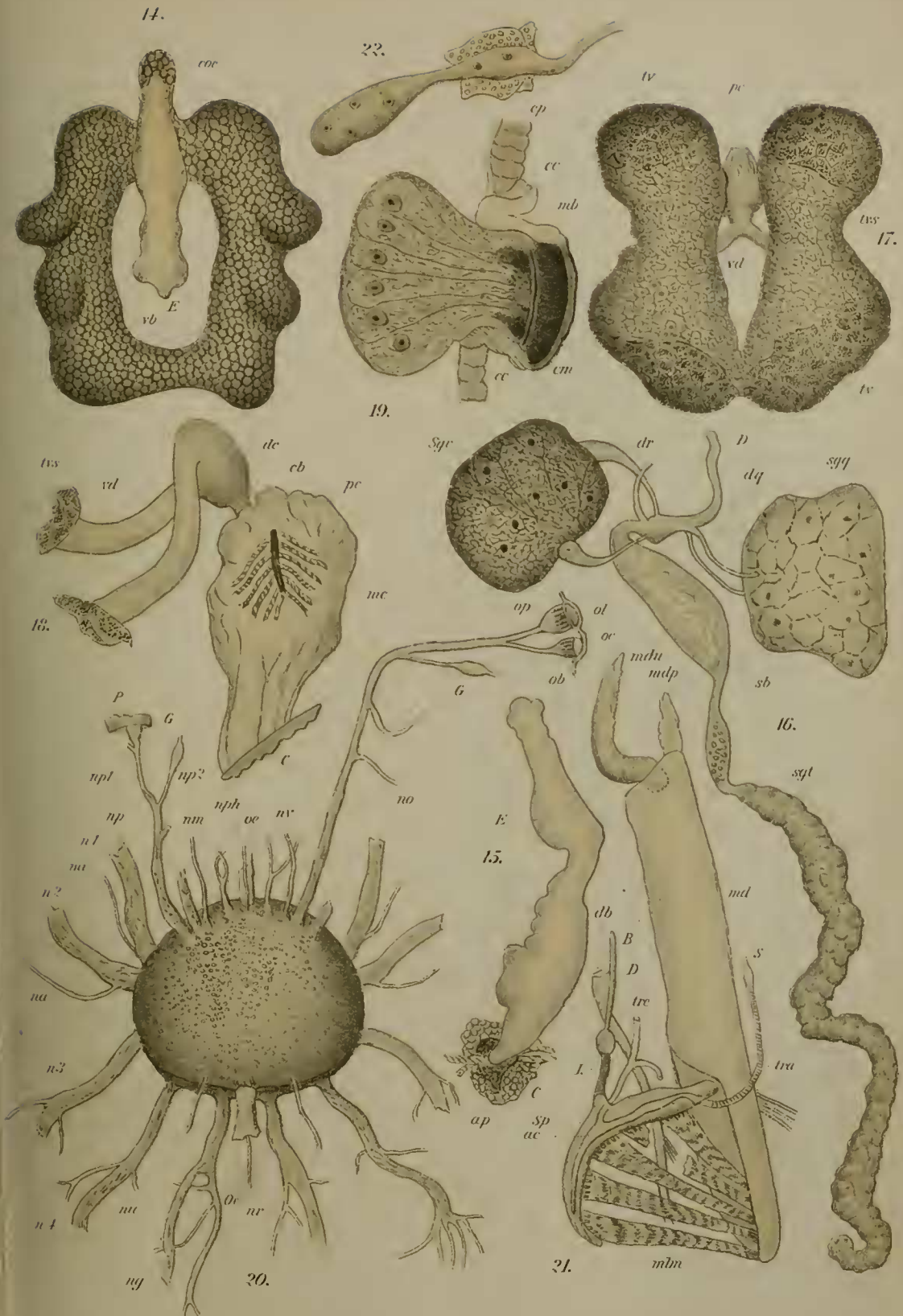
Contents.

The beautiful Acarid which forms the subject of this paper was discovered by my friend Mr. E. Bostock when we were collecting together in the neighbourhood of the Land's End, Cornwall; I have since met with numerous specimens in the same locality, but have not hitherto found it elsewhere. So far as I have been able to ascertain it has not been previously observed, and is unrecorded.



THYAS PETROPHILUS

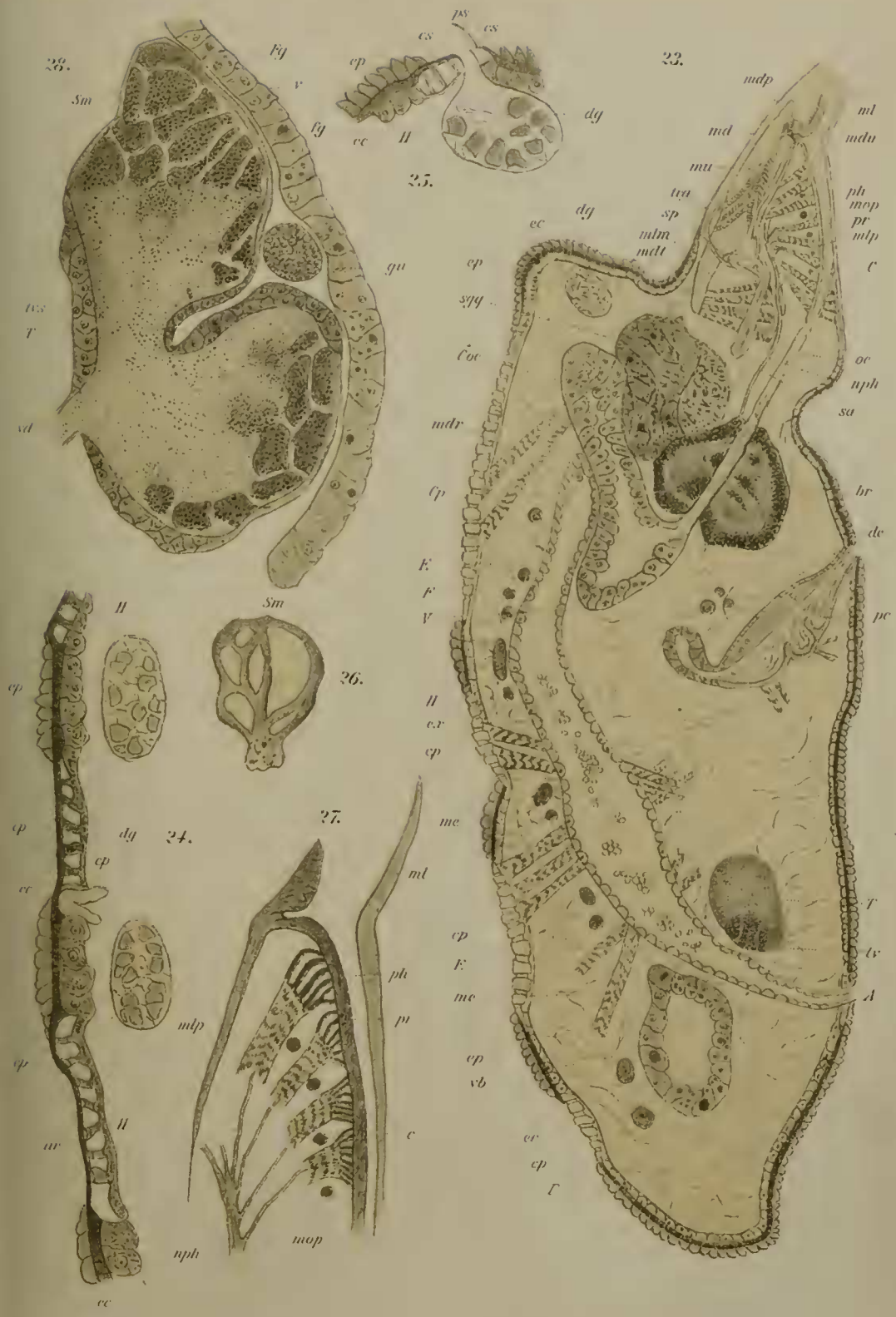
G. Freytag & Berndt, Vienna



THYAS PETROPHILUS

West, Newman del.

G. Freytag & Berndt Vienna.



THYAS PETROPHILUS.

G Freytag & Berndt Vienna


BRITISH MUSEUM
NATURAL HISTORY

The habitat of the creature is somewhat curious; it was found in a very small stream of fresh water, just where it comes tumbling over the granite cliffs and runs down the sands into the sea. The part where the Mites were found was the bottom, not the top, of the cliff; the stream there is distinctly fresh water, but is only three or four feet above high-water mark at the high spring-tides; so that when the wind is on shore and the sea at all rough considerable quantities of salt-water must be carried into the stream, and even at ordinary times a good deal of salt spray must reach it. I searched in vain for the Acarid higher up the same stream, and I have not hitherto succeeded in finding it in any of the other streams in the same district. Although a Water-Mite, it is not found swimming; like other members of the genus it is adapted for crawling only; but I have not ever seen it crawling on the bottom or on the water-plants, although of course it must do so. I have invariably found it either in small chinks and splits in the rock, where it can only be discovered by carefully chiselling away the rock in likely places, or clinging to the underside of large stones lying in deep pools; I thought from the latter position that the Acarids had been carried down the stream, but, as before stated, I was not able to find them higher up.

The Mite is very conspicuous when its hiding-place is discovered; it is of a beautiful scarlet colour shaded and varied with orange, and the soft cuticle is diversified by a number of porous plates of clear yellow chitin sunk a little below the general level of the skin, so as to form shallow depressions. The legs are one of the most striking features, as most joints are furnished with a radiating whorl of large yellow spines tipped with scarlet, which give a very brilliant appearance; the colours are difficult to preserve after death.

The Acarus appears to belong to the genus *Thyas*, the principal characters of which are as follows:—Hydrachnidæ with the eyes placed at the side of the body (far apart), with two-jointed mandibles, without swimming-hairs on any of the legs, and with the dorsal cuticle furnished with numerous separate chitinous plates. It is by the last-named character that the genus is finally distinguished from Kramer's genus *Aturus*.

I propose calling the new species *Thyas petrophilus*, from its habits of life.

THYAS PETROPHILUS, n. sp. (Plate VII. figs. 1, 2.)

	♂. mm.	♀. mm.
Average length including rostrum about	1·00	1·35
„ „ of rostrum only about	·10	·15
Greatest breadth about	·65	·70
„ thickness, dorso-ventrally, about	·40	·50
Length of legs, 1st pair about	·38	·50
„ „ 2nd „ „	·50	·65
„ „ 3rd „ „	·65	·85
„ „ 4th „ „	·85	1·10

Colour orange-scarlet, varying in different parts of the body in shades from orange to scarlet. Chitinous plates on the dorsal and ventral surfaces and the legs lemon-yellow; spines on the legs yellow tipped with scarlet.

Form oblong, corners rounded; compressed dorso-ventrally; dorsal surface flat, concave in young specimens.

Texture.—The whole cuticle of the body, where it is not chitinized, is covered by conspicuous rounded papillæ, having an average diameter of about ·005 to ·008 mm. The dorsal and ventral surfaces are, however, mostly occupied by numerous porous chitinized plates sunk in the cuticle; the epimera, sternal plate, legs, palpi, and maxillary lip are all chitinized and pierced by pores averaging about 150 to the millimetre on the epimera and sternum, and about 250 to the millimetre on the legs and palpi; while the actual pores themselves have an average diameter of about ·003 in the former, and ·001 in the latter situations.

Eyes crimson, placed at the antero-lateral angles of the body; the two eyes in each pair quite distinct. I cannot find any trace of a fifth median eye.

Maxillary lip (fig. 4).—This, as usual, forms a deep trough, slightly narrowed toward the anterior end, which is sharply truncated and slightly bifid.

Palpi (fig. 5) have the second joint the thickest, the fourth much the longest, the fifth a blunt claw. They are what is known as the *Hydrophantes*-palpus, *i. e.* the dorsal part of the fourth joint projects considerably parallel to the fifth, so that the fourth and fifth form a sort of chela.

Mandibles (figs. 3, 21) almost straight; the chitinous wall of the dorsal half of the first joint much longer than that of the ventral. There is a membranous anterior projection (*mdp.*) overhanging the second joint, which joint is hook-like, movable, and serrated on its upper (concave) edge.

Dorsal surface (fig. 1).—This is mostly covered by chitinous plates sunk in the cuticle, and which are usually at the bottom of small depressions; these depressions are formed partly by the drying up and often entire rubbing off of the portion of the external layer of the cuticle which overlies the plate, and partly by these plates giving points of attachment for the powerful dorso-ventral and other muscles, by which they are drawn downward (into the body) a little. These plates are of two kinds: one consists of large, or comparatively large, plates thickly and irregularly pierced by areolations of various sizes and shapes, but so large and numerous that the holes cover a larger area than the chitin; a small portion of one of these plates is shown at fig. 11. The second kind consists of quite small plates, mostly having some approach to the round or square form, and mostly with an almost circular opening in the middle and the rest of the plate pierced by fine pores more regularly placed than those on the larger plates. Each smaller plate bears a small hollow colourless hair or spine close to the central hole, if there be one, but the hair is always present; such hairs do

not occur on the larger plates. The larger plates are arranged in three irregular longitudinal rows; the same plate rarely exactly agrees in form or size in two individuals or on opposite sides of the body, and seldom, in form, even on the two sides of the same plate; but the arrangement may be said to be approximately as follows:—The central line consists of three unpaired plates, of which the anterior is much the largest, and much larger than any other plate on the body; it is heart-shaped. The central and posterior are nearer to a square or oblong form. The lateral rows are each composed of four plates of irregular forms; the hindmost is nearly triangular and approaches near to its fellow on the other side of the body. I am not sure that in some specimens some of these plates may not coalesce or be broken up into more than one.

The smaller plates generally form an irregular longitudinal line of four on each side, starting from between the first large central plate and the eyes and passing between the central and lateral lines of large plates.

The edge of the body.—There are some of the small plates, and one or two of the nature of the large plates, on the actual lateral and posterior edge of the body.

The ventral surface (fig. 2).—The epimera are arranged in two groups on each side of the body, those of the first and second leg being anchylosed together; and the same taking place with those of the third and fourth, but a strip of soft cuticle intervening between those of the second and third. Between the epimera of the first pair of legs, but not attached to them, is a plate formed of the fused sternal plate and maxillary lip; this plate does not extend as far back as the epimera do.

The body forms a lateral, almost square, projection between the epimera of the second and third legs.

There are, on the ventral surface, two pairs of irregular-shaped plates near the posterior margin, of the nature of the larger dorsal plates; four or five pairs of the nature of the small dorsal plates; the anal plate (if that be its proper name); a small plate just anterior to the anal and like it in form, but turned in the reverse direction; and, finally, the plates surrounding the genital opening. The anal plate (fig. 10) has a round central opening, which is the exterior orifice of the excretory organ and is closed by two soft labia. This opening is surrounded by a ring of chitin rather denser than the remainder of the plate, which ring is pierced by a regular row of very fine pores. A little further out is a concentric ring of rather larger pores, and the rest of the plate has pores similar to those in the epimera &c.

The sclerites surrounding the genital aperture are similar in both sexes, and consist of a small, anterior, median, almost triangular plate of rough chitin with the point directed forward, and two paired lateral plates, the shape of which will be best gathered from the drawing; these nearly touch posteriorly, but are further apart anteriorly. Two pairs of the so-called genital suckers are situated between these lateral plates, and one pair of larger ones behind and

outside their postero-lateral edges. The genital opening itself is a longitudinal slit closed by soft labia in both sexes.

The epimera of the first pair of legs are fringed on the edges nearest the median line of the body by a series of beautifully feathered or pectinated hairs (fig. 6), which vary considerably; three or four at the anterior are curled over at their ends and plumose, the remainder are some finely (fig. 8) others more coarsely (fig. 7) pectinated; most of them are terminated by a long fine spine, which is not pectinated. There are a few very small, curved, colourless hairs on the epimera and the hind margin of the body.

Legs (figs. 12, 13).—The legs gradually increase in length from before backward; they are entirely chitinized and entirely without swimming-hairs; they are terminated by strong didactyle claws; the tarsi, particularly the two hind pairs, are enlarged at their distal ends and excavated so as to form deep cups. All the legs are armed with a number of large orange-scarlet spines, or spines tipped with that colour, which form the most striking feature of the species; they are mostly lanceolate or laurel-leaf shaped, but some are straight; the largest are arranged in radiating whorls round the distal ends of the third and fourth joints of the first pair of legs and the third, fourth, and fifth of the other pairs: there are also two large spines, one on the underside of the second joint of each second leg, and several similar but smaller spines on the upperside of the same joints in the first three pairs of legs and the underside of the fourth; there is also a pair at the distal end of the tarsus of the third and fourth legs, curving over and protecting the claws. There are lines of somewhat similar, but uncoloured, spines on the outer edges of the fourth coxæ. There are numerous other hairs on the legs, particularly on the outer side of the fourth legs; these hairs are mostly strongly curved, colourless, soft, and diminishing to a point; there are smaller fine hairs on the tarsi.

The Integument (Plate VII. fig. 11; Plate IX. figs. 23, 24, 25).

This varies in thickness in different parts of the body; it may be said to consist of three layers, or it might be considered two layers, the outer being double. Treating it as three layers, the outer, which may be called the "epiostracum" (fig. 24, *ep.*), consists of a single row of epithelial cells, rounded or conical on the outer side, flat on the inner side; these cells form the papillæ with which the soft parts of the body, particularly the dorsal surface, are coated externally. They are loosely arranged and vary in form a good deal in different parts of the creature; those towards the anterior end being, as a rule, the most papillose. The second layer, which may be called the "ectostracum" (figs. 24, 25, *ec.*), consists also of a single row of cells; but they are more cubical and form a dense and thoroughly united tissue with a flat surface on both sides: otherwise the cells are no doubt of the same nature as those of the outer layers, the latter being more or less transformed or perishing. The inner layer (figs. 24, 25, *H.*), which may be called the "end-

ostracum," is the living layer or hypoderm. It is in the cells of this layer that the chitin is deposited which forms the chitinous plates of the cuticle. The cells in which the chitin is deposited occasionally increase greatly in size, the swelling being inward: so that at the enlarged point the chitin projects further into the body than the other portions of the cuticle (fig. 24, *cp.*, the hind end of the first plate), and the larger plates are so abundantly pierced by large irregular holes or areolations that in section the chitin often looks like detached rods, or laminæ. The chitin is often thinner at the edge of the plate than elsewhere, and in that case gradually diminishes to an edge at the periphery, so as to present a knife-edge section. The chitin here is pierced only by smaller pores, not by the large areolations. The cells of the hypoderm generally send protoplasmic tongues into the areolations, often entirely filling them. Above the chitinous plates the epiostracum often persists, as observed by Schaub in *Hydrodroma*: when it does so it most usually dries up and becomes a very thin layer of dead flattened cells; but the compression or crumpling of the convex outer side produces a greater thickness or opacity in the middle of the cell, which gives the plates a somewhat spotted appearance over the areolations. Most commonly, however, particularly on the dorsal surface, the epiostracum not only dries up but rubs off and is entirely lost; the ectostracum also, in the same cases, dries up above the plate and becomes an extremely thin layer; so that the two outer layers of the cuticle over the plate are not nearly so thick as in other situations; hence the plates of the dorsal surface lie at the bottom of shallow depressions; this applies to the larger areolated plates only, not to the small hair-bearing plates.

The larger plates give attachment on their inner sides to the dorso-ventral and other muscles.

The Dermal Glands (Plate IX. figs. 23, 24, 25, 26).

The general arrangement, comparative size, and position on the dorsal surface of these glands, which are so well-known in the Hydrachnidæ, is very similar to that described by Schaub in *Hydrodroma* and by Haller[1]; the glands are not, however, so strictly confined to the dorsal surface as they seem to be in *Hydrodroma*; there are some on the edge of the ventral surface near the anterior and posterior ends of the body. The glands themselves differ considerably from those described by Schaub, inasmuch as they are entirely without the chitinous external coating and the chitinous network of strengthening ribs which that author found; they are enveloped simply by a soft membranous tunic, and are formed of large, delicate, very loose cells, in which a nucleus is rarely to be detected: these cells stain but slightly, and the greater number are usually found to have broken down, either during the life of the specimen or during its preparation. There

[1] "Die Arten und Gattungen der Schweizer Hydrachnidenfauna," Mittheil. der Schweizer entom. Gesellsch. 1882, p. 18.

is also occasionally an irregular central protoplasmic mass, and the whole is joined by delicate threads. It seems not improbable that the absence of chitinization from the exterior tunic of these glands may be correlated with the much greater chitinization of the external cuticle in *Thyas* than in *Hydrodroma*. Schaub and Haller appear to have found that the mouth of each of these glands was surrounded by a thick ring of chitin, and was in connection with a more or less triangular chitinous sclerite bearing a small spine, which may be regarded as protecting the opening; neither of these conditions, however, is to be found exactly in *Thyas petrophilus*. The dermal glands of this species discharge to the exterior either through a largish central hole in one of the numerous smaller chitinous plates in the cuticle (fig. 25, *cs.*), each of which plates bears a small hollow spine (*ps.*), or else at the edge of a plate, usually in the former manner; the sclerite is, however, distinctly a plate with numerous pores, which bears both the hair and the mouth of the gland; there is not one solid ring-like ridge surrounding the mouth and another triangular ridge supporting the hair. I have not been able to make certain of any really definite connection between the dermal glands and these smaller dermal plates, as it seems to me that the number of plates does not agree with the number of glands, and that some of the plates have not the central opening; it is, however, extremely difficult to be absolutely sure on this point.

In a few instances I have found near where the duct emerges a minute and extremely delicate membranous sac within the gland, which sac contains an almost globular structure formed of open irregular network, which stains deeply (fig. 26).

The Alimentary Canal and Excretory Organ (Plate VIII. figs. 14, 15; Plate IX. figs. 23, 27).

I join these two systems, because, in effect, it is impossible properly to separate them in the Hydrachnidæ, and indeed in some other families of the Acarina, *e. g.* the Gamasidæ.

The alimentary canal in *Thyas petrophilus* differs considerably from everything which, to my knowledge, has been described in the family, or indeed in the Acarina at all; although undoubtedly it is a modification of the same general plan.

At the entrance from the mouth to the pharynx I find organs which I suppose are those described by Schaub as "palpenartige Gebilde"; I am not, however, able to regard them as of the nature of palpi; they seem to me, in my species at all events, to be small masses destined either to fit together very closely, and indeed to interlock, and thus form a valve closing the entrance to the pharynx, or else to be separated at the will of the creature, thus completing the pharynx in its office as a sucking apparatus.

The pharynx itself with its muscles (figs. 24, 27, *ph.*) has the same lanceolate form shown by Schaub in *Hydrodroma*, and has an average length of about ·15 mm., by a breadth, in its

widest part, of about ·03 mm.; when, however, we come to the construction of the pharynx, and indeed to the question of what really is the pharynx, I do not find that my species at all agrees with Schaub's description and drawings. Of course, as I have not seen Schaub's species, I cannot in any way deny that he is correct as to that species; but if he be, then it seems to me that his species must be quite exceptional, differing entirely not only from what I believe I see in *Thyas* &c., but also from what Croneberg has described in *Eylais*, and Henkin in *Trombidium*. The appearance is so similar in all these cases that the investigator is tempted to doubt whether the difference may not be one of interpretation rather than of actual construction; it is, however, not merely a difference of small detail but of principle. If we refer to Schaub's Taf. i. fig. 1, we shall find that he draws the pharynx (*ph.*) as a fusiform sac continuous in a straight line with the œsophagus, and lying above and upon what he calls a chitinous floor ("Chitin Boden") (his *ch.* 2), into the top of which floor the long, almost perpendicular, muscles coming from above are inserted; this floor he makes joined at its end to a lower chitinous floor (*ch.* 1), which forms the true floor of the mouth; so that the two together form a V with the point directed backward and not allowing any food to pass between the two limbs of the V, or at all events not to pass beyond the point of union of these two limbs. If we now turn to Schaub's Taf. iii. fig. 6, which is a horizontal section through what he considers to be the pharynx, we find that he considers that organ to be divided into numerous compartments by what he calls disks ("scheibenformige Querflächen"), each compartment containing a ring-muscle which constricts an extremely fine tube passing longitudinally up the middle of the pharynx; this tube he says is the true throat ("Schlundrohr"), through which the food passes. There is not anything to show how this throat expands again when the ring-muscles are relaxed; it would seem to be probably too delicate to do so from its proper elasticity. If we now refer to Henkin's figs. 5 and 7, we shall find that (in *Trombidium*) he draws most of the similar parts, but puts a totally different interpretation upon them. Schaub's upper chitinous floor (his *ch.* 2), to which the muscles are attached, is Henkin's "upper wall of the throat"; Schaub's lower chitinous floor (*ch.* 1) is Henkin's "under wall of the throat"; Schaub's disks are represented (in Henkin's fig. 7) by the tendons which attach the long perpendicular muscles (Henkin's "sucking muscles") to the upper wall of the throat; the upper and under walls, when at rest, still form the V shown by Schaub, but they are not joined at the point, and when the sucking-muscles contract the upper wall of the throat is raised, a sucking action is the result, and the food rushes in between the two walls. The fine tube which Schaub calls the throat has not any existence in Henkin's descriptions or figures, nor are any ring-muscles to be found, but the latter are represented by transverse muscles (called by Henkin "swallowing muscles") in the following manner:—The upper and under walls of the throat are not flat surfaces; they are half-tubes like the rain-

water gutters placed round the roofs of houses; they both have the convex surface downward and the upper rests upon and within the under; the edges, not the ends, are joined in a slightly flexible manner, and the whole upper wall is more or less flexible, elastic, and movable, while the lower wall is stiffer and more fixed. Thus, when the sucking-muscles (*mlp.*) contract and the upper wall is raised, a crescent-shaped lumen is formed in the pharynx (or throat). The pharynx is contracted again partly probably by its own elasticity, but chiefly by the transverse muscles (Henkin's swallowing muscles) which run straight across from one edge of the half-tubes to the other (his fig. 5, my figs. 23, 27, *mop.*), one band of transverse muscle alternating with each band of perpendicular muscle. Henkin was not the first to describe this arrangement; Croneberg drew and described it most exactly four years previously in *Eylais*; but I have above referred to Henkin rather than to Croneberg because the former gives a sagittal as well as a transverse section, which makes reference easier, and Croneberg shows the pharynx and the œsophagus in the same transverse section, which I do not quite understand; moreover, Croneberg's paper is in Russian. A similar construction was given by MacLeod in 1884 for *Trombidium*, *Hydrachna*, and *Erythræus* [1].

Coming now to the present species, *Thyas petrophilus*, I find the pharyngeal arrangement to agree entirely with Croneberg's and Henkin's descriptions, and not at all with Schaub's; I have examined it with great care by sections in every direction and by dissections, and I cannot find a trace of Schaub's thin tube, his "true throat," while the food certainly seems to pass between the two chitinous floors as Henkin says (figs. 23, 27, *ph.*). The long perpendicular muscles, which I will call the dilatores pharyngis muscles (figs. 23, 27, *mlp.*), raise the roof of the pharnyx (Schaub's *ch.* 2), principally in the median line along which they are attached, and the food rushes in between it and the chitinous floor; the roof by the action of the muscles having been separated from the floor and at its posterior end become continuous with the upper wall (or roof) of the œsophagus, which seems above it when the dilator muscles are not in action. The valve before described now closes the anterior end of the pharynx; the contraction of the transverse muscles (depressores tecti pharyngis or contractores pharyngis) brings the roof and floor close together and drives the food into the œsophagus, its return from which is prevented by a valve. Such, at least, is my reading of the action of the parts; at all events I do not think that there can be any doubt that the passage for the food from the mouth to the œsophagus in *Thyas petrophilus* is below, not above, the chitinous plate, to which what I call the "dilatores pharyngis" are attached. I may say that I have carefully examined similar parts in two or three species of *Trombidium* and other allied creatures, and in every instance have found the construction the same. I have also examined them in

[1] "La structure de l'intestin antérieur des Arachnides," Bull. Acad. R. de Belgique, 1884, nos. 9, 10.

some Oribatidæ, e. g. *Cepheus latus*, which, as it eats partly solid food, has a wider œsophagus and pharynx, and shows more plainly, and there the principle is practically the same; although, to admit of the larger extention, there are some muscles for depressing the floor of the pharynx, and there are undoubtedly ring-muscles on the œsophagus. In the Gamasidæ, although the principle is somewhat similar, I have found considerable differences of detail, and even of more than detail [1].

The mode in which the dilatores pharyngis muscles are attached to the roof of the pharynx in *Thyas petrophilus* is particularly beautiful; I have not seen anything like it drawn or described in other Acarina to my recollection; therefore I have figured it (fig. 27). The muscles of the Acarina are attached to their point of insertion either directly or, more commonly, by means of tendons, which are often very long. Where several separate muscles, or a fasciculus of muscles, are inserted together, their separate tendons usually join some little distance from the point of insertion and form a common tendon; in the present instance, however, the dilatores pharyngis are mostly strap-like muscles passing diagonally from where they arise to their insertion; each muscle appears quite separate, each may possibly be a band of muscles attached by their edges; but it has not any appearance of being so, nor does it differ from the appearance of other strap-like muscles which are each attached by a single tendon. In the present instance, however, each muscle widens out a little towards its inserted end, and that end is attached to the point, or rather line of insertion, by four or more separate tendons varying from about ·005 mm. to about ·015 mm. in length and which diverge a little, thus giving the muscle a grasp over a large surface of the pharyngeal wall which it has to raise; a similar arrangement is found in some of the other broad muscles of the present species, but not so well developed. These dilatores pharyngis muscles are innervated by a special azygous nerve (figs. 20, 23, 27, *nph.*) arising from the supra-œsophageal portion of the brain (or central ganglion) almost immediately above the œsophagus, and running parallel to and above the œsophagus, until the pharyngeal muscles are reached, when it divides, sending off a twig to each dilator muscle. The whole course of this nerve may be beautifully seen in one or two of my preparations. I call it the pharyngeal nerve. I do not find that Schaub says where his phanyngeal muscles are innervated from, but Henkin (in *Trombidium*) draws and mentions this nerve, but does not appear to have traced it to its origin. Croneberg in his fig. 16, *Eylais*, draws two paired nerves, which he letters "*n*, *n*"; they come, so far as I can judge, from the supra-œsophageal portion of the brain; each divides into two equal branches very near its origin. In the explanation of his fig. 16, Croneberg says that "*b*, *b*" are the nerves going to the pharynx and mandibles; but there is not any

[1] "On the Variations in the Internal Anatomy of the Gamasinæ, &c." Trans. Linn. Soc., Zool. vol. v. pt. 9, p. 310, pl. 73.

"*b*, *b*" on the plate, and I think it is a misprint for "*n*, *n*"; I am not able to read Russian, but I fancy they are referred to in the text as "*n*, *n*." They appear to be the same nerves as Schaub letters "*ant.*" and says go to the mandibles and palpi. In his subsequent work on *Trombidium* in 1879, Croneberg draws the azygous nerve starting from the brain and passing above the œsophagus, although he does not say where it goes to.

The œsophagus (fig. 20, 23, *œ.*) is a tube about ·25 mm. long and of about even dimensions throughout; it runs right through the brain in the usual manner, and enters the lower part of the ventriculus in the median line about ·02 mm. behind the brain.

The ventriculus (figs. 14, 23, *v.*) presents very considerable differences from any hitherto described; those figured by Schaub, Henkin, Croneberg, &c., both for Hydrachnidæ and Trombidiidæ, consist of a broad viscus, flattened dorso-ventrally, occupying the greater part of the dorsal surface of the creature, and furnished either with numerous shortish, cæcal, mostly paired diverticula which arise from the dorsal surface and edges of the ventriculus, as shown by Croneberg for *Eylais*, or with a smaller number of diverticula of somewhat larger dimensions, as found by Schaub and Henkin in *Hydrodroma* and *Trombidium*. Of these cæca the posterior median pair turn forward in Schaub's species and backward in the others; Henkin figures and describes them as having their hinder parts pressed together in the median line. In *Thyas petrophilus* I find near the brain a short anterior tract of the ventriculus, which is rather deeper than it is long; *i. e.* it has a horizontal antero-posterior measurement of about ·1 mm. and a perpendicular dorso-ventral measurement of about ·11 mm. in its deepest place, *i. e.* where the œsophagus enters. There is an unpaired median cæcum (*cœ.*) about ·15 mm. in length, which projects forward and slightly upward; it has a somewhat clavate distal extremity and lies immediately over and upon the quadrate salivary glands, where they press against each other in the median line. From the sides of this, which I consider the ventriculus proper, two expansions, as wide as the ventriculus proper, run laterally and form a shallow rounded lobe on each side; they then run straight backward and continue up to about ·1 mm. from the posterior end of the creature, maintaining their full width throughout; they have two shallow irregular lobes on their outer edge and a tendency to a lobate projection of the posterior corner; they then turn inward and *join* without showing any sign of demarcation. The result of this is that the whole ventriculus forms what would be called a ring if it were round instead of square. As it exists it is a hollow square with shallow lobes at the angles, rather more strongly-marked lobes on the outer sides, and a single azygous cæcal diverticulum in the anterior median line. The lobes vary somewhat in different specimens, but the general plan is the same. The whole hollow-square must be considered to be the ventriculus; *the lumen is continuous throughout.*

The dorso-ventral muscles and the excretory organs pass through the hollow of this square. It is not very difficult to imagine how this state of things, exceptional as it is, arose; if we turn to a different family of Acarina, the Gamasidæ, we shall find usually a very small ventriculus, with a pair of small anterior and one or two pairs of long posterior cæcal diverticula: in the Oribatidæ we have a larger ventriculus and a single pair of posterior diverticula, often very long. If we suppose a creature with the small ventriculus of the Gamasidæ and the single pair of long cæca found in the Oribatidæ, and suppose these cæca pressed together at their posterior ends, as in Henkin's description of *Trombidium*, we have only to suppose that these two cæca coalesce at their point of contact, and that, the walls becoming obliterated, a continuous lumen is formed, and we have the ventriculus of *Thyas petrophilus*. It is true that we must imagine the coalescence to be so perfect that not a trace of the origin from two paired cæca is left.

The hind gut and excretory organs must be treated as one question; authors are not by any means agreed upon the construction or homologies of these parts in the Hydrachnidæ and Trombidiidæ. Croneberg describes the ventriculus as a viscus closed posteriorly, and not having any connection with anything in the nature of an anus: he says, in fact, that in all the species of both families which he investigated there is an entrance for food into the ventriculus, but not any organ for the discharge of fæcal matter; it must be confessed that at first sight this appears improbable. Croneberg draws an opening on the ventral surface of *Eylais* between the fourth pair of legs which has the appearance of an anus, and which in his figures he letters "*an.*," although I am told that anus would not be quite a correct translation of the Russian expression in his explanation of his plates. In his German paper on *Trombidium*, however, he calls the opening anus "After"; but in both papers he says that it has not any connection with the alimentary canal but only with the excretory organs, and he draws and describes a single clavate sac overlying the ventriculus in the median line, but ending blindly in front, and not having any entrance into the ventriculus, but passing along the median line of its dorsal surface and bending down behind it to the opening "*an.*" on the ventral surface; this organ he describes as being filled with the white matter so abundantly found in the Malpighian vessels of many other Acarina, *e. g.* the Gamasidæ. Croneberg's view by no means agrees with the previously expressed opinions of Pagenstecher, who considered Croneberg's excretory organ to be the rectum, and characterized Dujardin's earlier suggestion that an *Acarus* might be without an anus as an excursion into the realms of fancy. Henkin found in *Trombidium* an arrangement similar to that described by Croneberg, but although he could not find any connection between the ventriculus and Croneberg's excretory organ he thought that there must be one and that the latter must be regarded as the hind gut.

Henkin says that where this organ overlies and touches the ventriculus, the investing membrane (or tunica propria) becomes vague, and that he thinks that there must be communication at this point, although he could not find it. After this came Schaub's paper on *Hydrodroma*: he described a very different state of affairs; he saw all that Croneberg and Henkin saw, and a great amount more; he agrees with Croneberg that the excretory organ which opens at the so-called anus does not communicate with the ventriculus; but he says that this opening is not the anus at all, but is simply the opening of the excretory organ, and that, in *Hydrodroma*, the same chitinous plate on the ventral surface which contains the so-called anus also contains a much smaller opening, immediately anterior to the other, which is the true anus; he draws and describes a well-developed hind gut leading from the ventriculus to this true anus in addition to, and quite separate from, the excretory organ. Schaub remarks correctly that previous writers had not observed this smaller opening, except Halder, who calls it a preanal opening[1], and only noticed it in *Hydrodroma*; he is inclined to object to former authors having called the larger opening the anus, and he suggests that it is scarcely probable that *Hydrodroma* is the only Hydrachnid which possesses an anal opening—a reasonable observation enough.

A year later Schaub published a very interesting paper on marine Hydrachnidæ, giving, *inter alia*, numerous anatomical details relative to two species of *Pontarachna*; but, oddly enough, in these he only draws a single opening which he calls anus, just as previous writers had in other species, without saying whether it was the point of discharge of the alimentary canal or of the excretory organs or of both.

Coming now to *Thyas* I find precisely the state of things described by Croneberg. I find a single longitudinal slit-like opening (figs. 10, 23, *A*.) closed by two labiæ and situated in a small chitinous plate (fig. 10, *ap*.) in the median line of the body about halfway between the epimera of the fourth legs and the posterior margins of the body. I have most carefully examined this plate and the surrounding parts in many specimens, and I cannot find any trace of a second opening such as Schaub describes; to this single opening one organ and one only goes; this organ is the excretory vessel described by all the authors, and its whole inner surface is usually thickly clothed with the white excretory matter before mentioned. There is not any second viscus such as that figured by Schaub; the ventriculus ends blindly (fig. 23, *v*.). The excretory organ overlies it in the central line, and even hides almost all of its azygous anterior diverticulum when looked at from the dorsal side; it then turns downward, passing through the large opening left by the hollow-square form of the ventriculus in this species, and goes to the opening before described. This organ certainly ends blindly in front, and although

[1] "Die Arten und Gattungen der Schweizer Hydrachnidenfauna," Mittheil. d. Schweizer entom. Gesellsch. 1882, p. 18.

it overlies and touches the ventriculus for a considerable distance, yet I am utterly unable to find any sign of a communication between the two. There is not any point where the outer coat of the excretory organ becomes vague as in Henkin's *Trombidium*. I have carefully examined sections, cut in all directions, with high powers, and the tunica propria appears continuous and most distinct everywhere, and in some specimens the two organs do not quite touch anywhere, there being a distinct space between with connective tissue joining them. I know how difficult it is sometimes to detect communications, and therefore I will not absolutely deny that anything of the kind exists; but I am decidedly of opinion, however improbable it may seem, that it is true that the mid-gut ends blindly, and that the excretory viscus which ends in the anus-like opening (fig. 10, *A*.) has not any communication with the mid-gut. The improbability is diminished when we consider that these creatures do not swallow any solid food, but live entirely by suction, feeding on the blood of other minute creatures which they capture; still, of course, a Spider or a Gamasid lives in the same way, but has a distinct hind-gut and anus. In the present instance, however, I have not ever seen food in the organ, as we should expect to do if it were in direct communication with the ventriculus; I find the white excretory matter and that only.

With regard to the homologies of the organ, if it were not for Schaub's species, I should say that it appeared to me that the anus-like opening was the true anus, and that the excretory organ which leads to it was the homologue of the hind-gut; although in consequence of the nature of the food, or for some other reason, the hind-gut had become severed from the mid-gut and had lost its function as a hind-gut, assuming that of the Malpighian vessels found in Gamasidæ, &c. I have not ever seen Schaub's species: but if we can rely, as we naturally suppose we may, upon his investigations, which I believe were conducted in Professor Cohn's laboratory at Vienna, then the presence in so closely allied a species of a second anal opening, and of a well-marked and functional hind-gut, in addition to the excretory organ and opening, would seem to prove beyond question that in other species, such as the present one, the hind-gut and anus have become obsolete, and that the excretory organ is of the nature of a Malpighian vessel, or at all events of the organs which bear that name, whether properly or not, in the Gamasidæ, &c, and in many other Arachnida, e. g. *Mygale*, &c., although it discharges to the exterior instead of into the hind-gut between the colon and the rectum, which is the point of discharge in Gamasidæ, &c.

The form of the excretory organ (fig. 15, and figs. 14, 23, *E*.) is very much that shown by Schaub, viz. an elongated sac with a rounded, cæcal, anterior extremity, varying and irregular in its diameter, but widening out so as to form a pyriform expansion before it suddenly narrows to reach its point of discharge. This widened part is generally compressed dorso-ventrally by folding and compression. These folds are quite irregular and do not

always occur; when they do they are not usually bilaterally symmetrical, or probably in any way permanent; they often are found to a lesser degree in other parts of the sac, and evidently provide for considerable extension and contraction of the lumen of the organ. The folding sometimes is found in directions where it would probably not result from dorso-ventral compression.

In regard to the homologies of the alimentary canal and excretory organs, it may not be immaterial to remember that Wagner[1] has lately found that in the embryo *Ixodes* the so-called Malpighian vessels are formed from the endoderm quite separately from the proctodeum, and only become connected with that organ in the latest stage of development. The histology of the alimentary canal does not present any features varying sufficiently from what has been described by other authors to make it necessary to notice them. The tunica propria is particularly clear and well marked. The lumen of the ventriculus is large, its walls composed of more closely-placed cells, forming a more even layer than is usually found in the ventriculus of Acarina; the cells are large but not so loose nor rounded as in most species, and the large groups of rounded cells projecting into the lumen and gradually becoming detached and dropping off into it, correctly figured by Henkin in *Trombidium*, are far less abundant here. These remarks apply specially to the male, in which, as far as I have seen, the amount of food-material absorbed by, and contained within, the cells of the ventriculus is less than in the case of the female, where the cells are often greatly distended by it.

Salivary Glands (Plate VIII. fig. 16; Plate IX. fig. 23).

I use the expression "salivary glands" for the glands which I am about to treat of because that expression is in general use for them; I am not, however, satisfied that it quite correctly expresses their function.

These glands are often largely developed in the Acarina, probably most so in the predatory kinds. It is already well known that some species of Hydrachnidæ are amply provided with them; in the present species they assume considerable importance. Croneberg found three pairs of glands, each pair having bilateral symmetry, two pairs being more or less kidney-shaped, while the third pair are more sausage-shaped. Croneberg only draws and describes the portion of these later glands near to, and including, the efferent end, apparently not having traced them further. In his fig. 33 he draws the kidney-shaped glands as composed of numerous, largish, closely-pressed secreting-cells with clear nuclei, and the sausage-shaped glands as composed of a single layer of squarish cells surrounding a small lumen; he shows the three glands on each side of the body as communicating by small ducts with a larger joint efferent-duct. Schaub also found three pairs

[1] "Beiträge zur Phylogenie der Arachniden," Jena. Zeitschr. f. Med. u. Naturw. 29 Bd. (1894) Heft i. pp. 125–152.

of salivary glands very similar to Croneberg's—two pairs which he calls kidney-shaped, and one which, following Croneberg, he properly calls pipe-shaped or tubular (schlauchförmig); this gland he says has its blind end fixed to a chitinous projecting piece or band arising from the anterior edge of the body near the side of the rostrum, and about the level of the top of the brain; the gland then runs nearly straight backward until it reaches a point about one-third of the length of the body (without rostrum) from the anterior edge of the body; the gland then makes several twists on itself, running across the body toward the median line, but not reaching it; then runs forward again, soon loses its twisted character, and approaches its point of origin, thus forming a nearly complete loop, and ends in a long fine duct running toward the mouth. Schaub was not able to trace this duct to its point of discharge, nor was he able to determine with certainty whether the two kidney-shaped glands and the tubular gland on each side join in a common efferent duct, as Croneberg says, or not; but he says that if they do, in his species, the juncture must be very near the mouth, as he has traced the three separate ducts a long way; he seems to me to doubt their joining at all. Croneberg describes a tubular salivary gland in *Trombidium* with a course very similiar to that given by Schaub[1]; and Pagenstecher had described it in 1860.

In the present species there is a very decided resemblance to the condition described by Croneberg and Schaub; the general scheme of the salivary organs is undoubtedly homologous, but the whole thing is more elaborated and the differences in detail are numerous and of some importance; on the whole, Croneberg's species and description come nearer to *Thyas petrophilus* than Schaub's do. In the species which I am describing there are at least three pairs of salivary glands (I will explain later on why I use the expression "at least"), two of these are clearly the homologues of the kidney-shaped glands and one of the tubular gland. If the creature be opened on the dorsal surface, and the dorsum and fat-body and other surrounding organs be removed, it will be found that just anterior to, and a little to the side of, the brain is a gland which may fairly be described as reniform (fig. 16, *sgr.*); it represents the "larger dorsal mouth-gland" of Schaub, which it greatly resembles in general appearance; a very similar gland was described as long ago as 1860 by Pagenstecher (in *Trombidium*), although his details may not be quite correct, and in 1861 by Gudden in reference to the Tyroglyphidæ[2]. This gland in *Thyas petrophilus* is formed of large secreting-cells radiating almost from a centre: these cells have an exterior measurement of about ·02 mm., and a length, measuring from the exterior toward the centre, of about ·08 mm.; they have large, very clearly-marked

[1] "Ueber den Bau von *Trombidium*," Bull. Soc. Imp. d. Nat. de Moscou, 1879.

[2] "Beitrag zur Lehre von der Scabies," Würzburger medicinische Zeitsch. 1861, p. 301, and zweite vermehrte Auflage, Würzburg, 1863.

nuclei of about ·01 mm. diameter, usually placed very regularly, which are best seen in sections. The size and shape of the whole gland varies a good deal in different individuals, and probably at different times, but the average size may be considered to be about ·1 mm. by about ·07 mm. Although this is the larger of the two kidney-shaped salivary glands in Schaub's species it is not so in the present instance, the representatives of the other of the two being somewhat larger. This latter pair of glands (figs. 16, 23, *sgq.*) cannot be called kidney-shaped in the present species, each is more square with advancing rounded corners; they are not regular in shape, varying considerably in different individuals &c., still they preserve their general form; they are flattened dorso-ventrally, and lie rather further back than the kidney-shaped pair; they are pressed against one another in the median line; and their posterior portions overlie and hide the anterior part of the brain, when seen from the dorsal side. The average size of each of these glands is about ·11 mm. square. Simply for the sake of clearness I will speak of them in this paper as the "quadrate salivary glands." In spite of this general agreement in the form and position of these two pairs of glands with those described by Schaub and Croneberg, there is one leading point in which there is a very marked difference from them, and indeed from all similar glands yet described in the Acarina; and that is, that all the authors describe their glands, doubtless correctly, as discharging by a single duct; in the present species each of the four glands discharges most distinctly by two paired ducts (*dq.*, *dr.*): whether this indicates the original derivation of each gland from two which have coalesced, I am not prepared to say; they do not show any other signs which I can detect of a double origin; but the two ducts are clear and unmistakable. In the kidney-shaped glands the ducts spring from opposite sides of the gland a considerable distance apart; they are largest in diameter where they leave the gland (about ·01 mm.) and gradually diminish, their smallest part being where they enter the main general duct (there they are about ·004 mm.) (fig. 16, *dr.*). The two ducts from each quadrate salivary gland (fig. 16, *dq.*, fig. 21) spring from the underside of the gland near its anterior edge; they arise some small distance apart, but considerably nearer together than those from the kidney-shaped gland; they are also much finer and more transparent than those from the last-named gland, and enter the main general duct together, joining just before they enter. They often overlie one another; thus while it is perfectly easy to see the two ducts from the kidney-shaped glands, it requires very careful dissection to demonstrate those from the quadrate glands; one of these must be dissected off, turned over to expose the under surface, and the two ducts separated with a very fine hair: if this trouble be taken then the two ducts are perfectly apparent, and their whole course may be traced to their entrance into the main general duct. I now come to the tubular salivary glands (fig. 16, *sgt.*); these, although essentially "tubular glands" are very different from, and much more

complicated than, those described by Schaub and partially described by Croneberg. In the first place, instead of their blind distal end being attached near the mouth it is attached to the side of the body about halfway back and opposite the genital organs: the gland is not in any way bent into a loop; its direction is forward for its whole length, but it is greatly and irregularly corrugated and twisted for about two-thirds of its course; in this part it has an average diameter of about ·02 mm., is a fleshy organ composed of largish secreting-cells, and has a very small lumen. The gland suddenly narrows at the end of this portion, loses its twisted and corrugated form, and becomes straight; it is still somewhat fleshy in appearance, and has a diameter somewhat less than half the diameter of the corrugated part; its largest diameter is in the centre, and it narrows at both ends to about half the diameter of the centre. This tract of the gland may be considered as the duct; it is usually filled with small round granules (secreted matter), very similar to that spoken of by Schaub in the distal portion of his tubular gland and by Croneberg in the same portion in *Trombidium*; except that, in consequence of the larger diameter of the organ now being described, the granules do not follow each other in single file as they do in Schaub's drawing. After this portion the duct suddenly expands again and becomes a large transparent ovate bladder, with thin, apparently structureless walls (fig. 16, *sb.*). The diameter of this bladder in its widest part is larger than that of any other portion of the whole duct; at its anterior end it narrows sharply, and there is a very short tubular part which turns suddenly downward and backward to join the main general duct. This description is not taken from a single specimen, all the numerous specimens which I have dissected have been alike. The only record at all resembling this bladder is Pagenstecher's respecting *Trombidium*.

It now remains to describe the precise manner in which the various glands above described communicate with the common duct (main general duct). There is one of these common ducts (*D.*) on each side of the body, and all the three salivary glands on that side communicate with it; it is of an almost uniform diameter until near its posterior end, where it enlarges somewhat suddenly both in a lateral and in a dorso-ventral direction; the small anterior end or prolongation of the bladder of the tubular gland enters the common duct in the middle line of the upperside of this enlargement, and the two ducts from the reniform gland enter the lateral edges of its upper part, one on each side. The two ducts from the quadrate salivary gland enter the tubular part of the common duct close together some distance nearer to the mouth than the entrance of the ducts from the reniform glands. At the posterior end of the lower part of the enlargement of the common duct, another tube (*du.*), which at its starting point is of nearly as large diameter as the tubular portion of the common duct but rapidly diminishes and becomes very fine, runs at first backward and then almost perpendicularly downward. I have not been able

to ascertain with certainty whether this tube ends blindly or is the duct of a fourth salivary gland; my opinion is that the latter is correct and that the tube is a fine duct coming from a small roundish gland lying close to the reniform gland. It is for this reason that I say above "at least three pairs of salivary glands," but as I have not been able to trace the communication with certainty I have thought it best not to draw this gland. The common duct runs to the upper surface of the chitinous bridge or lamella which is joined at its edges to the inner sides of the maxillary lip and forms a chitinous endo-skeleton in the rostrum upon which the mandibles rest. The commom duct penetrates this chitinous bridge, and runs forward for a short distance practically within its substance; the duct terminates by a bell-shaped mouth (*db.*) on the underside of the chitinous bridge.

In addition to the paired glands above described, there is an azygous sausage-shaped gland (fig. 23, *asg.*) practically in the median line of the hind part of the rostrum. It is about ·11 mm. long, with a diameter of about ·02 mm., is a fleshy organ with an extremely small lumen, and lies between the paired fan-shaped groups of muscles which run from the sigmoid piece to the mandibles (see page 203). The duct from this gland is short and fine, and runs straight forward towards the buccal chamber.

I have said above that I doubt whether there is sufficient evidence to justify us in asserting positively that the function of all these various glands is salivary only.

The Male Genital Organs (Plate VIII. figs. 17, 18; Plate IX. figs. 23, 28).

The male reproductive system differs in a remarkable degree from anything which has, to my knowledge, been hitherto described among the Hydrachnidæ, or, indeed, in any of the allied families. Schaub, for instance, in his species found a group of five pyriform testes on each side discharging by a common duct, which duct joined with its fellow from the opposite side to form a short unpaired duct leading into a long, much convoluted, duct, which he calls the vas deferens: this terminated in a short penis surrounded by muscles. Croneberg's *Eylais* shows a complicated network of testes entirely unlike anything found in the present species. Probably the nearest described organs are those of the species of *Trombidium* figured by Croneberg in his later work, 'Ueber den Bau von *Trombidium*'; but even these present most material differences from the form I am about to describe.

In *Thyas petrophilus* there is, on each side of the body, what appears to be a large testicular mass (figs. 17, 28, 23, *T.*), which immediately underlies the lateral portion of the ventricular ring. This testicular mass has an average length in fully-formed specimens of about ·3 mm., by a thickness in a dorso-ventral direction of about ·17 mm. in its thickest part. This mass is comparatively flat on its under (ventral) surface, and comparatively, although not quite, straight on its inner side; but it is formed into two

lobes by the swelling and rounding of its dorsal and lateral surfaces both anteriorly and posteriorly, leaving a thinner and narrower portion between, but without any breach of continuity or line of demarcation; the whole forms one piece. The mass varies a good deal in form in different specimens, and even the two sides of the same individual are seldom quite similar, but the general shape always corresponds fairly well. The masses on the two sides of the body are a short distance apart anteriorly, but approach each other closely posteriorly: almost at their hinder ends they are joined by a short bridge (fig. 17) quite continuous with both sides, so that the organ on both sides of the body forms one unbroken whole. From the ventral surface of the narrower part of the testicular mass on each side proceeds a vas deferens of moderate length, which runs upward and forward. At its anterior (distal) end, which is nearest to the dorsum, this vas deferens joins its fellow from the opposite side of the body, and the two enter a short widish ductus ejaculatorius (figs. 17, 18, 23, *de.*) with very fleshy walls, which runs downward and a little forward. This organ is inversely pyriform, being narrowed at its distal end so as to discharge by quite a small opening into a very large penial canal (figs. 18, 23, *pc.*), which again is inversely pyriform, its largest part being near to where the ductus ejaculatorius enters; this canal proceeds almost perpendicularly downward. On the outside of the widest part of the canal is a chitinous bar (fig. 18, *cb.*), from which a series of diagonal muscles (fig. 18, *mc.*) spread out; so that those on the two sides of the body, acting simultaneously, would form powerful compressors. Longitudinal muscles also run from the ductus ejaculatorius to the inner side of the cuticle of the body close to the genital opening; thus the penial canal can be compressed longitudinally as well as transversely. The canal itself is a large, membranous, tubular organ, considerably and irregularly folded, so that the portion nearest to the ductus ejaculatorius is apt to form a series of pouches, and the more distal part a number of longitudinal folds converging to the genital aperture. This last-named part is not much hidden by muscles when the organ is dissected out, whereas the more bulbous proximal portion is almost surrounded by them. I have not been able to discover any chitinous penis such as Croneberg draws in *Trombidium.* The penial canal, as I have drawn and described it, is as at rest under ordinary conditions. I have not been able to examine it at the moment of coition, and therefore I am not able to say whether the membranous tube is evaginated—thus, in effect, forming a penis, which seems very probable,—or whether the sperm is simply deposited on the exterior of the female, or conveyed by the feet as observed by Koenike in *Curvipes fuscatus.*

The testicular mass appears to be one solid block (subject to the foregoing description of its shape), and there is not any line of demarcation or any membrane or division between its various parts; but still it is not really so. The greater part of it has an external coating of a single layer of large cells about ·015 mm. in diameter,

having very distinct nuclei of about ·004 mm. and nucleoli of about ·002 mm. (fig. 28). On the outer and upper part of the anterior region of the front lobe and the outer and upper part of the posterior region of the hind lobe, on each side of the body, this layer, although existing, is less distinct and regular; the cells are somewhat smaller and more broken: but on their inner side in these localities will be found two or three layers of much larger polygonal cells (*sm.*), often as large as ·04 mm., in which the nucleus cannot any longer be detected: these cells are the true sperm-mother-cells, and are usually crowded with spermatozoa in various stages of maturity according to the age of the cell. The spermogenous cells of the inner of these layers, when quite mature, burst and discharge their contents into the interior of the organ, which, although having the appearance of a solid mass, is seen when examined with a sufficient amplification to be a hollow viscus closely packed with sperm and secretion; thus the whole organ forms a combination of testis and vesicula seminalis. It is a sac, the walls of which are formed of a single layer of large cells, which give birth to the true spermogenous cells on their inner surface at certain parts of the sac. These sperm-mother-cells discharge their contents into the interior of the sac, which becomes so full that the lumen of the sac is obliterated and the whole appears like one solid mass. It is probable that the contents are mixed with other secretion, but I do not detect special accessory glands. In the vasa deferentia the cellulation of the walls becomes indistinct, and there is a slight tendency to corrugation; but in the ductus ejaculatorius we again find the wall composed of distinct fleshy cells with clear nuclei, similar in character to those composing the outer layer of the testicular sac but smaller. The penial canal is a thin and almost structureless membrane.

The Female Genital Organs.

These organs so closely resemble what has been before described by Schaub, Henkin, and others, that it is not necessary to say much about them. The ovary forms a flattened ring with two oviducts leading to an unpaired canal (the vagina) as in the described species; and, as in these descriptions, the eggs are formed upon the upper surface of the ring: the only observations which it seems desirable to make are, firstly, that the ova in *Thyas petrophilus* are not quite so strictly confined to the upper surface as in the other recorded species of Hydrachnidæ; in the main part of the ring they are so confined, but in the rear part and near the insertion of the oviducts they are formed on the edges, and even on the under surface as well as the upper. Secondly, that although in the nymphs and young adults the ring form of the ovary is conspicuous, the ring being open and dorso-ventral muscles passing through it, yet that in the adult, when the eggs are mature, they are so numerous and crowded on the inner edge of the ring, that, being matured in pedunculated oocysts, they fill up the whole

interior of the ring and cause it to look like a disk; although, of course, it really remains a ring in structure, and the muscles continue to pass through the mass of eggs just as they did through the ring. Thirdly, that there are a considerable number of fine and short contorted tubes, apparently of a glandular nature, surrounding the outer edges of the ovary, the exact course and connections of which it is extremely difficult to make out, which have not been mentioned by former investigators; they are apparently outgrowths and plications of the peripheral parts of the ring itself, and possibly function as accessory glands.

The (so-called) Genital Suckers (Plate VIII. fig. 19).

In some families of Acarina the external genital aperture is accompanied by the organs which are known by the name of "genital suckers." In the Oribatidæ and Tyroglyphidæ they lie actually within the genital opening, and are only exerted when in action or by means of pressure. They are, in these families, soft extensible organs, usually either two or three pairs, and certainly have the appearance of suckers. In the Oribatidæ they are of somewhat complicated structure [1], and are the only sucker-like organs on the body. The mode of coition of the Oribatidæ is not known; but these organs have been considered to be genital, *i. e.* copulative, suckers by Claparède [2], Nicolet [3], and others. In the Tyroglyphidæ they have been considered to fulfil a similar office by Fumose and Robin [4], and Nalepa [5]; but in these creatures the mode of coition is known, and it takes place by a bursa copulatrix at the anal end of the female. The male during coition is above, not below, the female; so that the supposed copulative suckers of the female cannot possibly touch the male during coition; and in most species the male only, in addition to these so-called genital suckers, is provided with a pair of what certainly are copulative suckers, placed near his anal end. These considerations, *inter alia*, led Mégnin [6] to deny entirely that these organs were suckers. He says that he has watched them in action, and that it is at the moment of the deposition of the egg by the female that they are exerted, and that they then guide the egg. Mégnin admits that this does not explain their presence in the male; he says that he has not ever seen them in action in that sex, but he suggests that they probably serve to break the adherence of the male and female after the termination of the coitus. The principal objection to Mégnin's view as to the

[1] 'British Oribatidæ,' by the present author. Ray Soc. 1883, vol. i. pl. F. fig. 11.

[2] "Studien an Acariden," Zeit. wiss. Zool. 1868, p. 511, taf. xxxvii. fig. 5 *bb*.

[3] "Histoire Naturelle des Acariens qui se trouvent aux environs de Paris" Archiv. du Muséum, t. vii. p. 415.

[4] "Mémoire sur les Acariens des genres *Cheyletus*, *Glyciphagus*, et *Tyroglyphus*," Journ. de l'Anat. et de la Physiol. (Robin's), 1867, pp. 591–592.

[5] "Die Anatomie der Tyroglyphen," Sitzb. k. k. Akad. Wien, 1885, p. 16.

[6] "Mémoire sur les Hypopes," Journ. de l'Anat. et de la Physiol. (Robin's), 1874, pp. 239–240.

female would appear to be that in the Oribatidæ, which possess precisely similar organs, there is a long extensible ovipositor through which the egg passes; so that it could not possibly be touched or guided by these "genital suckers."

Organs which must be homologized with and which greatly resemble these so-called genital suckers exist in the Hydrachnidæ, and are greatly developed in the genus *Hydrodroma*. They were noticed by Neuman [1] and Haller [2]. The latter, although he calls the organs suckers (Haftnäpfe), generally puts the word between quotation-marks, as if he did not wish to be responsible for the name. He pointed out that in this genus these suckers, although somewhat extensible, were externally convex chitinous knobs, and he gives a rough drawing of the chitinous parts. Schaub, in the work so often quoted (p. 46), describes two pairs of such organs, which he terms the "so-called suckers," and one pair of chitinous rings which he regards as true suckers. These last-named pair are on the membranous folds or labia, which are situated between the genital plates and border the genital opening; the two pairs of convex chitinous knobs are at the anterior and posterior ends of the genital plates themselves, not forming one piece with the plate, but each knob is described as capable of protrusion, and as being a hollow hemisphere with its convex side on the exterior of the body, *i. e.* downwards, and with a short thick bundle of striped muscles inserted into its concave or inner side, and practically filling the hemisphere. Schaub says that the position and arrangement of these muscles leaves no doubt that the organs subserve copulation.

In *Thyas petrophilus* I find three pairs of these so-called suckers—two pairs in the labia between the genital plates, and one at the posterior angles of the plates, all slightly, but only slightly, protrusible; in each case the plates are excavated to allow these organs to pass. The posterior pair are rather the largest, but in other respects all three pairs are alike; there is not any ring-like sucker as in Schaub's species. Each so-called "sucker" (I use the expression for want of a better one) is provided exteriorly with a strong hemispherical cap of homogeneous chitin, with the convex side to the exterior, as in Schaub's species; the chitin covers the whole exterior of the organ, is about ·004 mm. thick and of a light reddish colour (fig. 19, *cm.*). This chitinous cap is supported by an irregular-shaped band of thicker chitin of a clear yellow colour standing at right angles to the cap: this chitinous band is attached to the soft cuticle of the ventral surface of the body, and forms the margin of an opening in the cuticle which just allows the narrowest part of the organ to pass through it, both the cap and the inner part of the organ being larger than the opening. Thus in the chitinous cap and the external appearance and position the

[1] "Om Sveriges Hydrachnider," Stockholm, 1880, Kongl. Svensk. Vetenskaps-Akad. Handling., Band. 17, No. 3, p. 112.

[2] "Die Hydrachniden der Schweiz," Mittheil d. Bern. naturf. Gesellsch. 1881, Heft ii. p. 48 (1882).

organs in my species fairly correspond with those described by Schaub; but here the resemblance suddenly ceases: instead of the large simple bundle of striped muscles filling up the interior of the cap and arising from the other genital organs, we have an entire absence of muscles within the cap, although some small muscles are attached round it. The inner side of the chitinous cap rests upon the distal ends of a number of columnar radiating cells forming an even layer about ·016 mm. thick; these cells take stain very deeply and rapidly, so much so that it is difficult to prevent their staining too darkly if other parts are to be stained at all. The proximal ends of these cells rest upon a basal membrane (*mb.*) about ·003 mm. thick, which does not stain at all, and which is continuous with the external membrane of a solid pyriform mass of large elongated cells. Each cell is largest at its inner extremity and diminishes outward. All the cells converge toward the smallest part of the organ, *i. e.* the point where it passes through the hole in the cuticle; they then spread out again a trifle, and their distal ends abut on the inner side of the basal membrane before mentioned; the distal portion of each cell, *i. e.* the part between the hole in the cuticle and the basal membrane, stains darkly and rapidly; the rest of the cell much more slightly and slowly. Each cell near its larger (inner) end contains a large clearly defined nucleus with a distinct nucleolus, those in the respective cells being very regularly arranged.

The whole organ has a formation entirely different from what would be expected in a sucker, and indeed has much more the appearance of a sense-organ of some kind; *e. g.* it looks not unlike the simple ocellus of an insect. I do not for a moment suggest that such is its function; such a thing would be unlikely in the extreme; and I do not detect any sufficient nerve-supply to justify it if it were not; but I do suggest that, in this species at all events, the organs are not suckers, and that it seems not impossible that they may have some sensory function. It struck me at first whether they could be glandular, but I do not find any point of discharge, nor any signs of cells breaking down and emitting their contents; and it has to be remembered that they are present equally developed in both sexes. Of course I at once admit that the position of the organs is such as to render it most probable that they perform some office in connection with the genital organs.

Glands of unknown Function (Plate IX. fig. 28).

Lying immediately below the lateral portions of the hollow square of the ventriculus, immediately above the genital organs in both sexes, and about the middle (longitudinally) of the latter organs, exist a pair of almost globular, or slightly elliptical, organs of about ·04 mm. diameter in the male and about ·05 to ·1 mm. in the female. These organs (fig. 19, *gu.*) have every appearance of being glands; they are composed of distinctly-nucleated closely-

packed, elongated cells of about ·01 mm. diameter, and in section exhibit similar cellulation all through; they are quite solid without lumen; but I have not been able to trace any duct from them. I thought at one time that they probably discharged into the posterior part of the tubular salivary glands; but after careful investigation I am not, up to the present, able to state that this is the case, although the two organs are in tolerably close juxtaposition; and the function of the glands therefore remains uncertain to me.

The Palpal Organs (Plate VIII. fig. 22).

These organs might probably be included in the last section as glands of unknown function, but I do not wish to pledge myself to the assertion that they are glands, although I incline to think so. They are largish paired organs, one on each side of the body; the posterior portion is an elongated lobe with a rounded hinder end; about a third of the length of this lobe (the posterior third) lies under the brain, but is not in any way connected with it, there is a separate nerve from brain to palpus. The lobe runs in an almost direct course from below the brain to the palpus, but it diminishes considerably in diameter before reaching that appendage, and where it enters has less than one third of the diameter of the thickest part of the lobe. Within the first joint of the palpus the palpal organ swells out again and forms a second elongated lobe, not nearly so thick as the first; at its distal end this bends slightly downward, and enters the second joint, where it again diminishes in diameter, and then runs forward until nearly the distal end of the palpus, keeping an almost uniform thickness (the anterior part is not shown in the figure). The organ is composed of large irregularly-placed cells, as far as can be judged from the nuclei, which are few but very distinct and of considerable size; but I have not been able to detect the lines of demarcation between cell and cell in any of my preparations.

The organ is solid, *i. e.* there is not any lumen, and I have not been able to trace anything like a duct from it. I am not aware of anything which has been described in the Acarina which can be identified with it or considered the homologue of it; nor have I ever seen such an organ in any other species that I have examined: the structure most resembling it, that I am acquainted with, in the Acarina is the spinning-gland partly in the palpus of *Tetranychus*; but the present species is aquatic and there is not any reason to suppose that it has any power of spinning; moreover the palpi are not furnished with a spinneret, such as is found in *Tetranychus*. The palpus is almost certainly a raptorial organ, it assuredly is not tactile; but there is not any poison-fang or spine that I can discover, and the mandibles are evidently the killing-organs. For these reasons I think it best not to suggest a function for these palpal structures and to leave the matter for future investigation.

The Nervous System (Plate VIII. fig. 20; Plate IX. figs. 23, 27).

I do not know that upon this part of the anatomy I have many observations to describe relative to the present species which differ in very important matters from what has been before observed by other acarologists in various species; but still I think that there are some new points of considerable interest to be detailed; and moreover, as former anatomists have not been altogether agreed as to the distribution of the nerves, fresh investigations may be useful, although made upon different species, or even families.

The great central nervous mass in all Acarina which have been investigated is the so-called brain (*br.*); which is penetrated by the œsophagus, that organ passing right through it, generally in a more or less oblique direction, and being accompanied by tracheæ in the present species. Although the whole of this brain is one mass, yet its formation from a supra-œsophageal and a sub-œsophageal ganglion is usually fairly apparent; the latter frequently extending considerably further backward than the former. In the present species the distinction between the upper and lower ganglia is practically lost; the whole forms one almost, but not quite, globular mass (figs. 20, 23, *br.*) which, in the male, has a diameter of about ·13 mm. in a dorso-ventral, and of about ·1 mm. in an antero-posterior direction; it lies considerably nearer to the ventral than the dorsal surface, indeed its lower edge nearly reaches the ventral cuticle. This brain is situated about as far back as the second pair of legs; it lies below the salivary glands, and in front of the genital aperture, and is invested by a most distinct neurilemma, which is separated from the nervous substance by endosmosis if the organ be soaked in water. The œsophagus (figs. 20, 23, *œ.*) penetrates the brain in a slightly oblique direction, running backward and a little upward.

From just above the œsophagus there starts from the lower part of the supra-œsophageal portion of the mass a fine, central, azygous nerve (*nph.*), which runs almost parallel to, but a little above, the œsophagus for the whole length of that organ; it then splits up into a large number of separate twigs, one of which runs to each muscle of the sucking-pharynx. About this nerve I do not feel any doubt whatever; I have it in several preparations, and in one fortunate sagittal section of the creature I have the whole length of the nerve from the point where it issues from the brain to its ultimate distribution to the pharyngeal muscles. A precisely similar nerve has been figured by Henkin (*op. cit.* fig. 7) as existing in *Trombidium fuliginosum*. Winkler[1] has drawn a similarly placed nerve in *Gamasus*, but I imagine that he considers that it goes to the lingula, as he calls it the "Zungennerv"; he however identifies it with Henkin's.

Schaub does not mention any such median nerve as going to the

[1] "Anatomie der Gamasiden," Arbeit. d. zool. Ins. Wien, vii. p. 336, taf. iii. fig. 8 (1888).

pharynx, but he does mention a median nerve which he says goes to a central unpaired eye which he seems to have found in *Hydrodroma*. Croneberg says that the pharynx in *Eylais* is innervated from the first pair of nerves from the supra-œsophageal ganglion, which also supply the mandibles: this certainly is not the case in *Thyas petrophilus*; although, as will be seen below, I think that the mandibles are supplied much as Croneberg says.

It is very difficult to trace the finer nerves in the Acarina and to be certain that one has traced all that start from the brain, although the larger ones, such as the great nerves to the legs, are easily followed; but to the best of my judgment I have been able to trace, in addition to the azygous nerves, 4 pairs which arise from the supra-œsophageal portion of the mass, 1 pair which arise exactly on the level of the œsophagus but considerably to the side of it, so that I cannot say whether they are supra- or sub-œsophageal, and 5 pairs of large nerves, from the sub-œsophageal portion of the mass.

The first pair from the upper ganglion are a thin pair of nerves (fig. 20, *nm.*) near to the median line, and they appear to me, in the present species at all events, to supply the mandibles only—not the mandible and pharynx, as Croneberg says they do in *Eylais*. Schaub states that the mandibles in *Hydrodroma* are innervated by the same nerves as the palpi; this does not seem to me to be the case in *Thyas petrophilus*. As regards homologies in other families of Acarina, Winkler, in the Gamasidæ, where the mandibular nerves are conspicuous, found that the mandibles were innervated by special nerves not identical with those serving the palpi, and fairly corresponding with the pair I find in *Thyas*, although situated a little further back, which may probably be accounted for by the great retractility of the mandibles in *Gamasus*. Nalepa found the mandibles of the Tyroglyphidæ to be innervated by special nerves, different from those serving the palpi, and agreeing in position with those I am now describing. Henkin also apparently found the same thing in *Trombidium fuliginosum*.

The second pair of nerves from the supra-œsophageal portion of the brain arise somewhat from the dorsal suface of that organ; they are an extremely thin pair (fig. 20, *nv.*) and innervate the muscles which run from the dorso-vertex[1] to the maxillary lip and possibly other dorso-ventral muscles.

The third pair of supra-œsophageal nerves spring from nearer to the anterior edge of that region of the brain and are the large optic nerves (fig. 20, *no.*). These have been well described and figured by Schaub; they are long and large nerves, each dividing dichotomously near the distal end, and sending one branch to each of the two eyes on that side of the body, which are pressed so closely against each other as to appear like one double eye.

The only difference of any importance which I have found

[1] The dorsal exoskeleton of the posterior part of the cephalothorax.

between Schaub's description and *Thyas petrophilus* is that he shows two fine branches as springing from the optic nerve some time before the final division into two; I find three such branches quite plainly visible in dissections. Schaub says that these branches go to sense-organs in the dorsal shield; I have not been able to find such sense-organs in my species, which has not the peculiar dorsal plate of *Hydrodroma* in which they are situated, and I have not been able to trace where the three fine branches in my species go to: I have two or three dissections showing the whole course of the optic nerve from the brain to the eye, and showing these branches for some distance; but I have not been able to trace them to their destinations and I cannot follow them in the sections.

The fourth pair of nerves from the upper ganglion is a pair of very thin nerves from near the posterior edge of the brain (fig. 20, *nu.*), and which lie above and between the nerves serving the fourth pair of legs and the genital nerves: these nerves are extremely fine and difficult to trace, but are certainly present; I have not succeeded in ascertaining what organs they innervate.

The pair of nerves which proceed from the level of the œsophagus, so that it is hard to say whether they are supra- or sub-œsophageal, are shown at fig. 20, *np.*; they are long and substantial nerves and I have sections showing them well in their entire length. Each nerve, shortly after leaving the brain, forms a ganglionic swelling and then diminishes to its former size: about halfway between the brain and its destination it sends a very small branch downward; I have not been able to trace this to its destination. Some distance from its termination the principal nerve divides dichotomously, sending one branch (*np.* 1) forward and upward to the palpus, and the other (*np.* 2) forward and downward to the maxillary lip; a short distance before reaching which it forms a small ganglionic swelling.

This nerve is probably homologous with Schaub's nerve "ant," which he says serves the palpi and mandibles; of course this may be so in his species, but as the palpi are maxillary palpi and the maxillary lip in Acarina is formed of the fused maxillæ, the distribution to palpi and maxillary lip seems more what might be expected than that to palpi and mandibles. Schaub considered that the palpi were innervated from the supra-œsophageal; Croneberg from the sub-œsophageal ganglion. Nalepa (in *Tyroglyphus*) considered that the maxillæ were served by the sub-, and the maxillary palpi by the supra-œsophageal ganglion. In the present species it is, as before stated, impossible to say which ganglion the nerve belongs to.

Of the nerves clearly proceeding from the sub-œsophageal part of the brain-mass there are, firstly, the four pairs of great nerves proceeding to the four pairs of legs (fig. 20, *n* 1, *n* 2, *n* 3, *n* 4); as to the existence and position of which all writers are agreed; but all have hitherto described and figured them as unbranched nerves, at least no one has described any branches, although their

existence might be anticipated; it will be seen by fig. 20 that I find more than one branch to each leg of the two hind pairs, in the fourth leg in particular I find several branches.

Croneberg, Schaub, and Nalepa all found that each of the four leg-nerves on each side of the body was accompanied by a much smaller nerve running parallel to it, which they call the accessory nerve; they all describe and figure it, doubtless correctly, as springing from the brain itself. In the present species the arrangement is very different; in the first two pairs of legs these accessory nerves exist (fig. 20, *na.*), and may be plainly seen in dissections although they are small and fine; but *they do not spring directly from the brain* as in the cases observed by those authors: they spring from the respective principal leg-nerves a short distance from the brain, and are in fact the first branches of those nerves; indeed the only ones which I have traced, although probably others exist in the more distal parts of the principal nerve. The two hind pairs of legs are entirely without accessory nerves, either springing from the brain or from the principal nerves. It is true that branches a good deal like the accessory nerves in character spring from the principal nerve much further on its course (fig. 20, *n* 3, *n* 4), but they are so very much further away from the brain than the branches of the nerves of the two first pairs of legs, that they can hardly be considered the homologues of the accessory nerves; moreover these branches are paired, not azygous as the accessory nerves are. No one has traced the accessory nerves to their destination or offered any explanation of what they are. It seems to me that the present species probably affords the key to this problem; they are apparently really branches of the principal nerves, which, in the species described by Croneberg and others, and probably in the majority of allied species, have for some reason gradually come to spring more and more closely to the brain until at last they have ended by springing from the brain itself and not from the principal nerve at all.

The last pair of large nerves springing from the lower ganglion are a pair quite at the rear and near the median line (fig. 20, *ng.*), which innervate the genital organs; practically all authors are agreed upon this point. In the present species I find that the principal trunk of the nerve runs to the dorsal side of the genital apparatus, and there gives off numerous fine branches to the various parts; and also sends a large branch to the vagina or ductus ejaculatorius and penial canal, as the case may be, and the muscles which surround it; and this branch divides, sending secondary branches to the so-called genital suckers. The principal branch forms a distinct ganglion, from which the fine nerves that are distributed to the organs actually arise; and there are at least one or two small ganglia in connection with the larger trunk. The existence of such ganglia has been already indicated by Schaub and even by Pagenstecher in 1860. The branches from this

genital nerve are very numerous, and I am not prepared to deny that some of them may serve other organs not belonging to the genital system.

Besides these paired nerves there is a fine azygous recurrent nerve in the median line (figs. 20, 23, *nr.*) running below that portion of the œsophagus which lies between the brain and the ventriculus, and innervating the latter organ, or at all events the ventral surface of it.

The histology of the great nerve-centre does not appear to me to differ sufficiently from what has been described to need remark; the principal point which attracts attention is the great thickness of the structureless neurilemma, below which is a single layer of the usual small round cortical cells coating the fibrous material of the brain, but much less conspicuous than is generally the case in Acarina.

The Respiratory Organs (Plate VIII. fig. 21; Plate IX. fig. 23).

These do not vary very greatly in the present species from what has been before described; there are, however, some points worth recording.

The system is strictly tracheate, and the tracheæ are very numerous, very fine, and mostly unbranched or but little branched; it is bilateral. As is usual in the Hydrachnidæ hitherto examined, what may be considered as the central air-chamber on each side of the body is a somewhat S-shaped piece of chitin which I will call the "sigmoid piece" (figs. 21, 23, *sp.*); it is not, however, truly S-shaped in the present species, the lower half of the S being much more developed and curved than the upper. This piece of chitin is flattened laterally, and the two pieces are very near each other and consequently very near the median line of the body, one being on each side of the line, each is nearly at right angles to the mandible on its own side; the chitinous tube of the mandible is sharply cut away on its inner side about two-thirds of its length from the anterior end, leaving an oval hollow at the inner posterior third of the mandible into which muscles, tracheæ, &c. pass. The chitin of the mandible forms a concavity which rests upon the head of the sigmoid piece, which thus forms a fulcrum upon which the mandible works. From the concave side of the lower and hinder portion of the sigmoid piece arise five broad fasciæ of muscles (fig. 21, *mlm.*) arranged in a fan-shape; each fascia is attached to the sigmoid piece by numerous very short tendons similar to those attaching the pharyngeal muscles to the roof of the pharynx, but shorter. The five fasciæ converge and are inserted into the inner edge of the hind (cut away) portion of the mandible, each fascia being attached by more than one tendon; these tendons are less numerous, but slightly longer, than those at the sigmoid end. When these muscles contract they depress the posterior end of the mandible, and consequently raise its anterior end and claw, which, as will be noticed in figs. 21, 23,